Search for WH associated production at DØ

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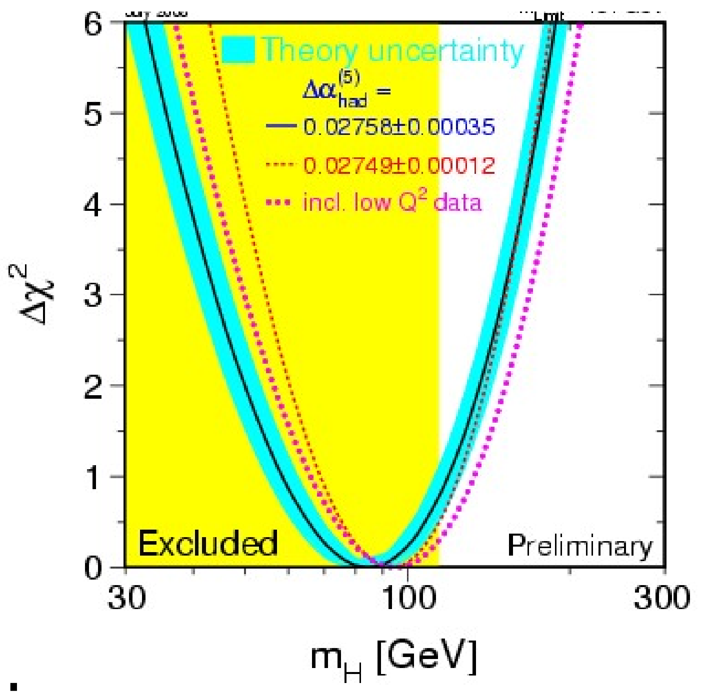
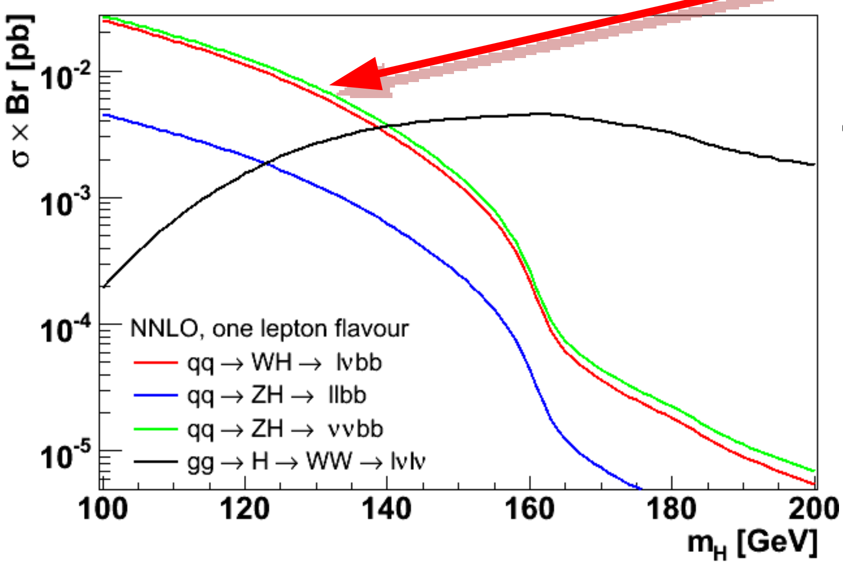
Motivation

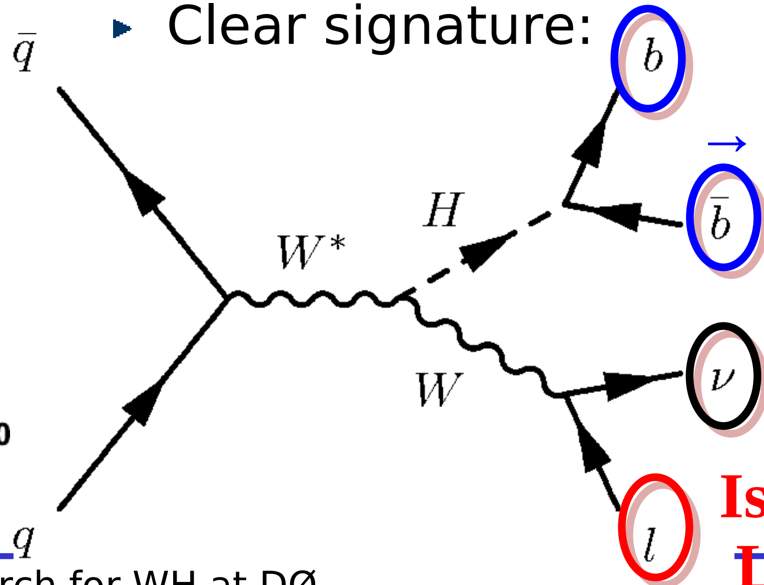
- Last missing particle in the SM
- LEP excluded m_H<114.4 GeV
- Global electroweak fits provides:
  - the upper limit m_H<154 GeV
  - Best fit : 84^{+34}_{-26} GeV
  - **Low masses preferred**



- WH→lνbb:
  - "High" σ x BR at low masses
  - Clear signature:



σ x BR vs m_H

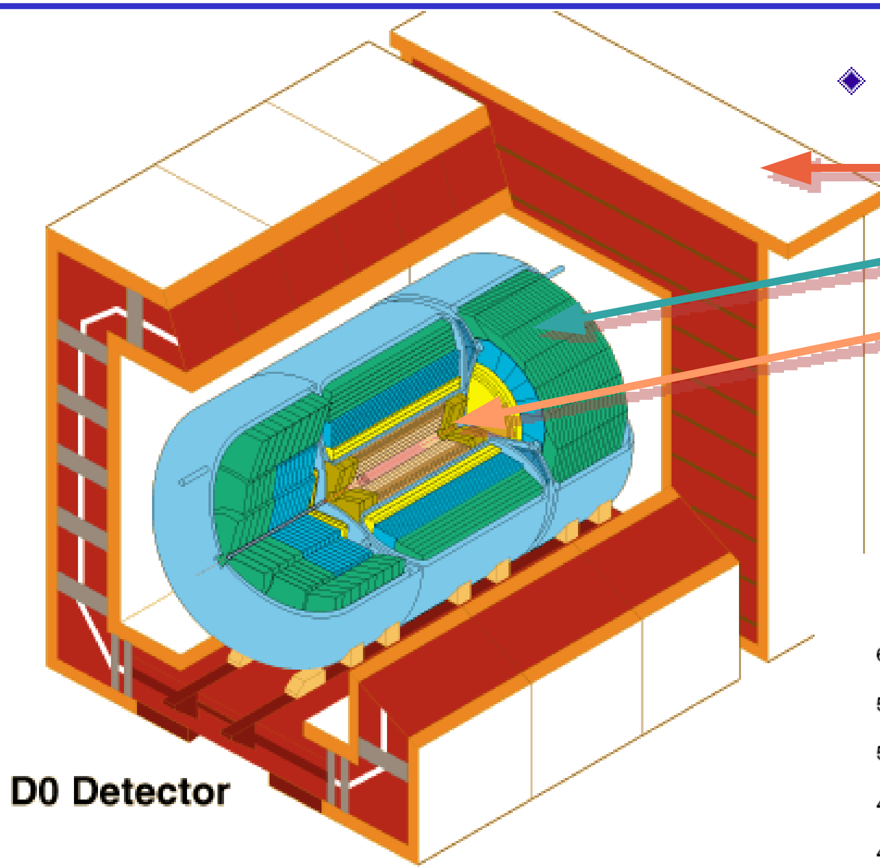


→ b-tagging

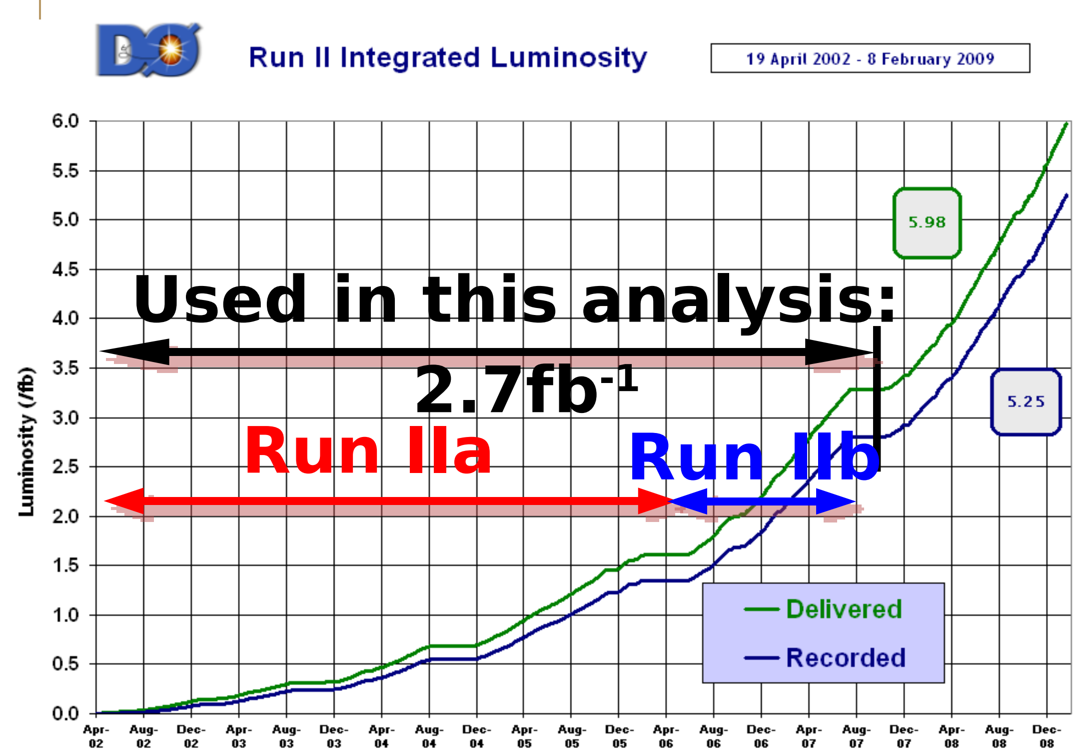
Missing energy (MET)

Isolated Lepton

Detector & analysis data sets



- DØ at Tevatron ($\sqrt{s}$=1.96TeV):
  - Muon chambers
  - Calorimeter
  - Tracker (incl. silicon vertex detector)



Background/signal simulation

- W+jets, Z+jets, tt contributions

  are evaluated using the **alpgen** generator (interfaced with **pythia**)

- WW, WZ, ZZ, WH($l\nu$bb)

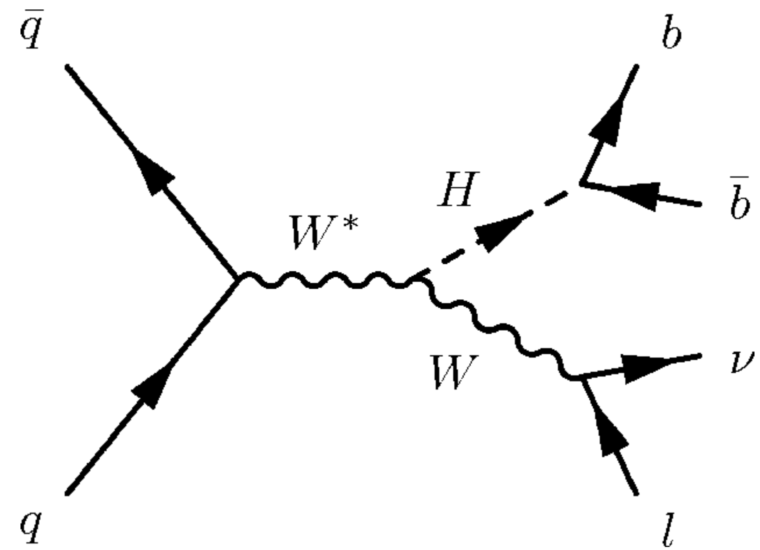
  are produced with **pythia**

- Single-top events
  - are generated with **comphep** (interfaced with **pythia**)

- Instrumental background (multijet events):
  - Jet can fake an isolated electron
  - Muon from a semi-leptonic heavy quark decay appears as isolated
  - **Estimated from the data**:
    - Probability for a lepton coming from a jet to be seen as isolated

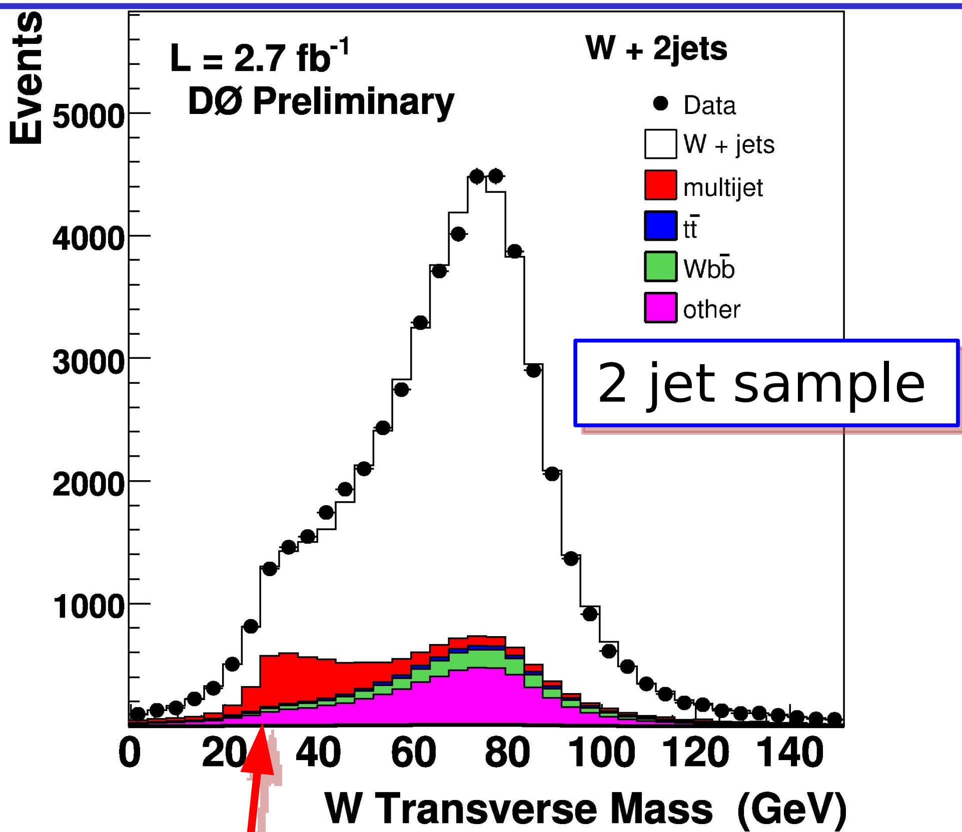
Selection

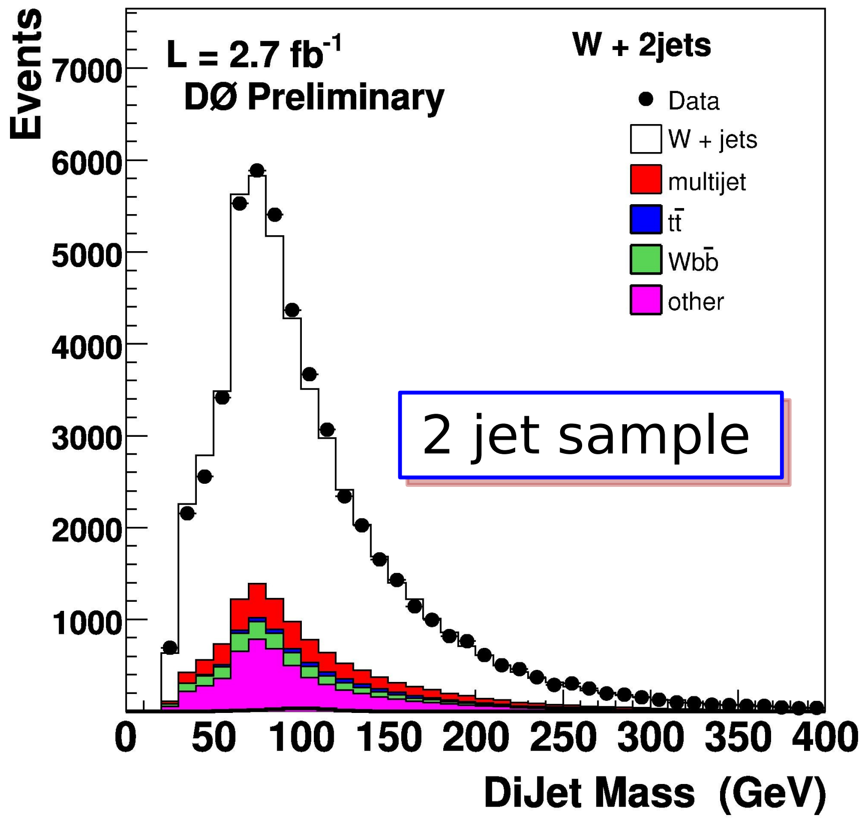
- Electron channel
  - Exactly one isolated electron :
    - pT>15 GeV, $|\eta_e|<1.5$ or $1.5<|\eta_e|<2.5$
  - MET>20 GeV (25 GeV if $1.5<|\eta_e|$)
- Muon channel
  - Exactly one isolated muon :
    - pT>15 GeV, $|\eta_\mu|<2.0$
  - MET>20 GeV



- Both channels :
  - **Divide the analysis into 2 parts**
    depending whether there are **2** or **3** jets (pT>20 GeV)
  - Σ pT(jet) > 60 (90) GeV in the 2 (3) jet sample
  - Cut against multijet background: M_T^W>40-0.5xMET
    - M_T^W: W transverse mass

Good agreement after selection



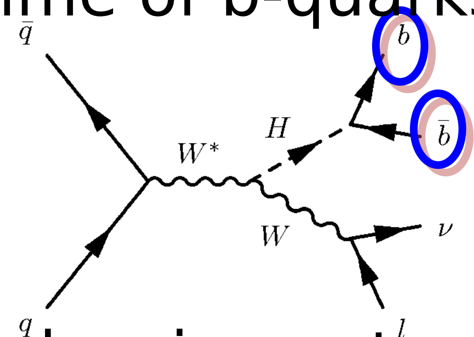


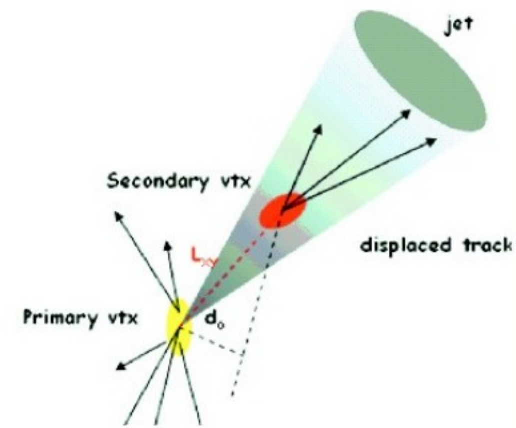
Mutijet background
at low transverse mass

Electron & Muon channels merged

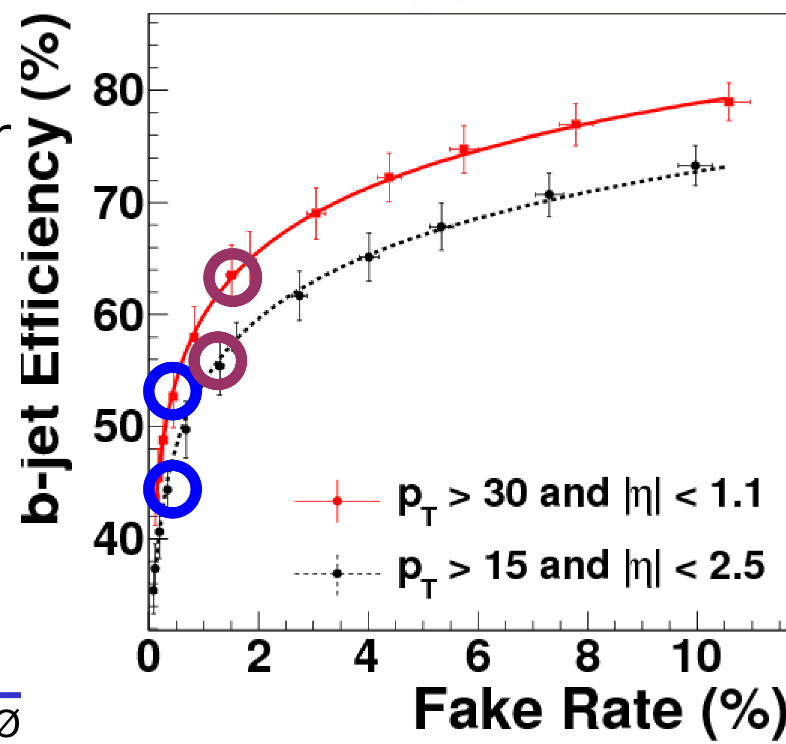
b-tagging

- Use long lifetime of b-quarks to improve the sensitivity



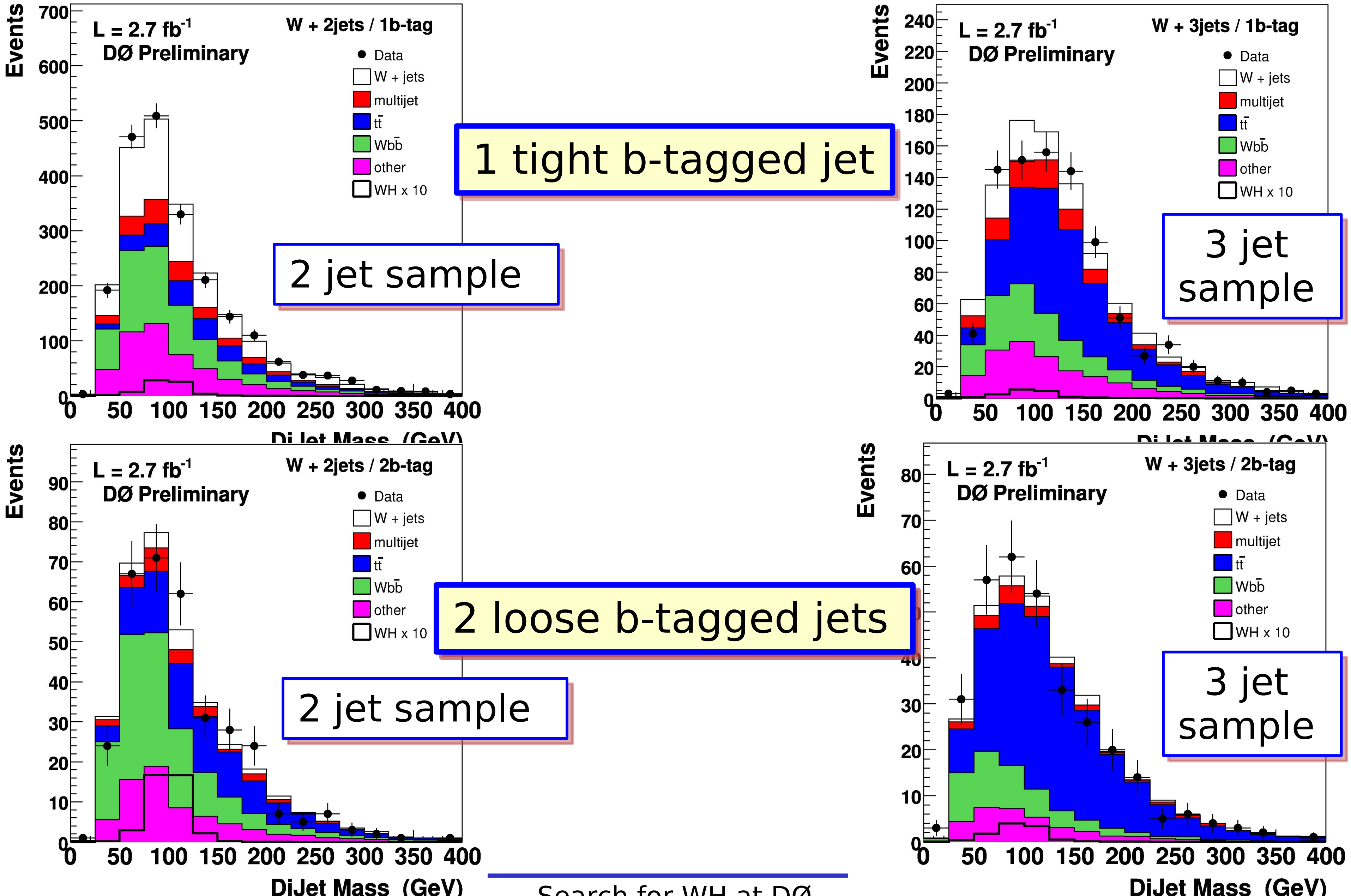


- Neural Network using outputs from other taggers:
  - Jet Lifetime Impact Parameter
  - Counting Signed Impact Parameter
  - Secondary Vertex Tagger



- Form 2 exclusive samples:
  - 2 **loose** b-tagged jets
  - 1 **tight** and 0 loose b-tagged jet

Good agreement after b-tagging



1 tight b-tagged jet

2 jet sample

3 jet sample

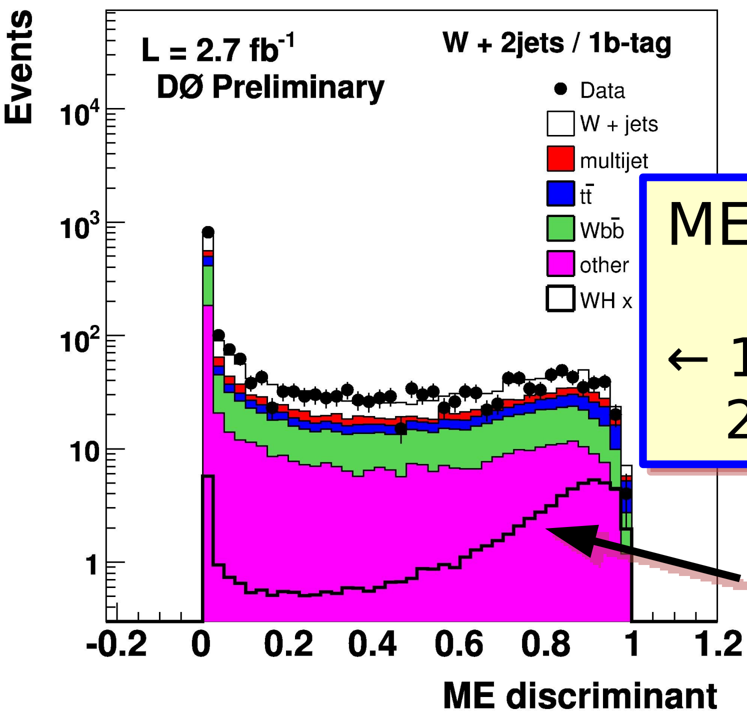
2 loose b-tagged jets

2 jet sample

3 jet sample

Multivariate techniques (1)

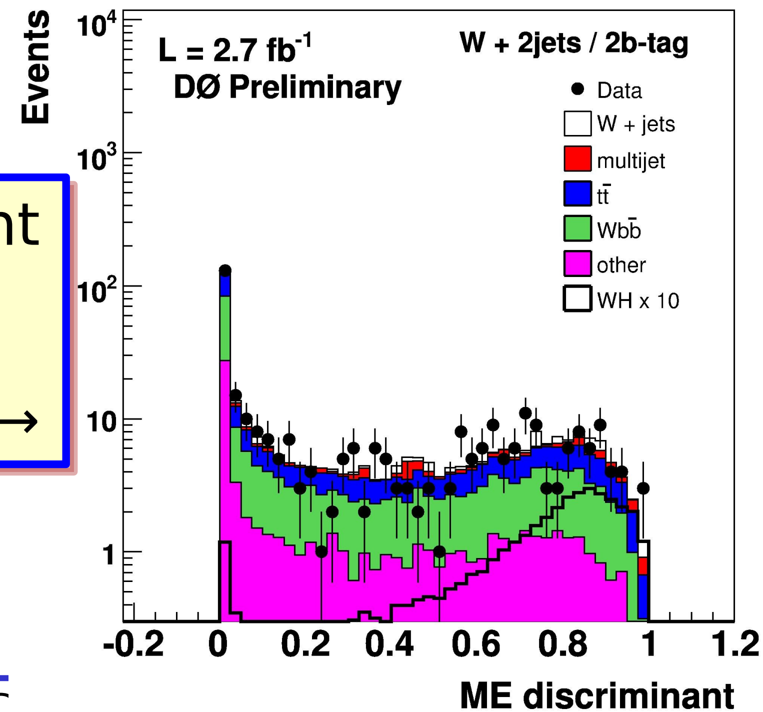
- Build a matrix-element based discriminant
  - **Using LO matrix elements**
  - → relative probability for an event to come from WH decay or background
  - Consider the **4-vectors of the lepton/jets**
  - Integrate over the neutrino momentum
  - Convolve with the resolution function of the detector



ME discriminant (2 jets)

← 1 tight b-tag

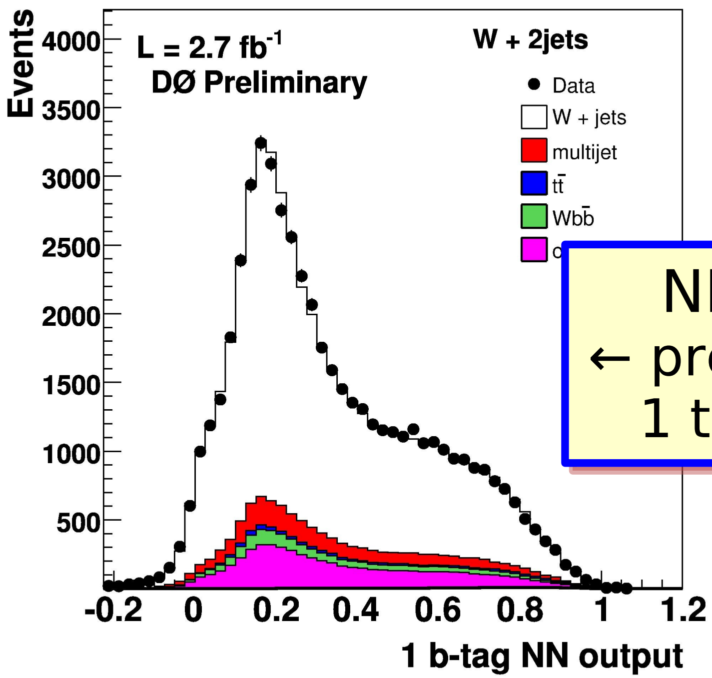
2 loose b-tag →



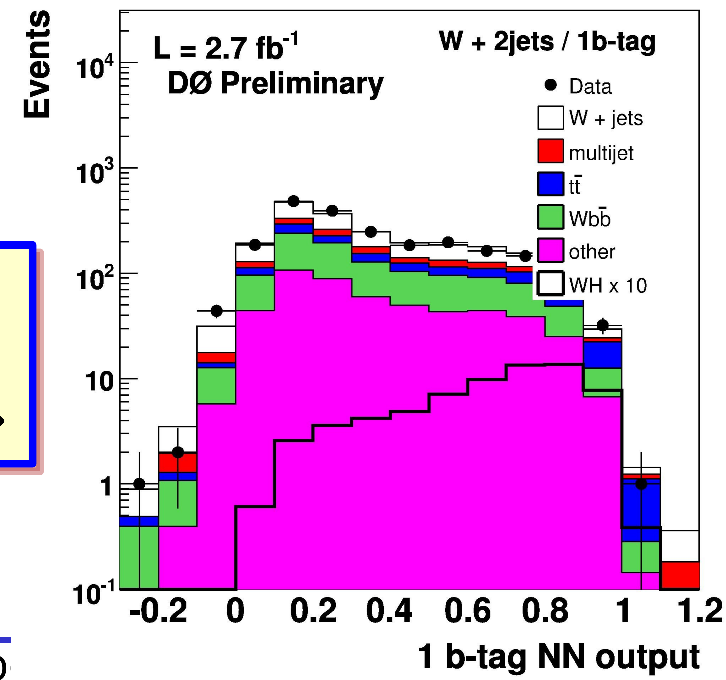
Multivariate techniques (2)

- Increase the sensitivity in the 2-jet sample with a neural network (NN) using as inputs:
  - Matrix element discriminant
  - pT's, ΔR, $\Delta\varphi$, invariant mass of the 2 leading jets
  - pT of the dijet system
- 8 trained NN's: electron/muon X 1-/2- tags samples X RunIIa/RunIIb

  → Gain of 20% of sensitivity wrt M(jet1, jet2) only



NN output
← pre-b-tag
1 tight b-tag →



Systematics uncertainties

- Main uncertainties
  - Cross sections: 11-20%
  - Shape of the Wjj dijet invariant mass: 10%
  - Shape of the Wbb dijet invariant mass: 5-10%
  - Lepton reconstruction/identification: 5-6%
  - Jet identification/calibration: 2-6%
  - Jet fragmentation: 5%
  - Trigger efficiencies : 3-5%
  - b-tagging efficiency:
    - 2-5% (per heavy quark jet)
    - 25% (per light quark jet)

Results

- No excess of events observed → set limits using...
  - the NN output (2-jet samples)
  - di-jet invariant mass (3-jet samples)

- ... for the 16 individual analysis

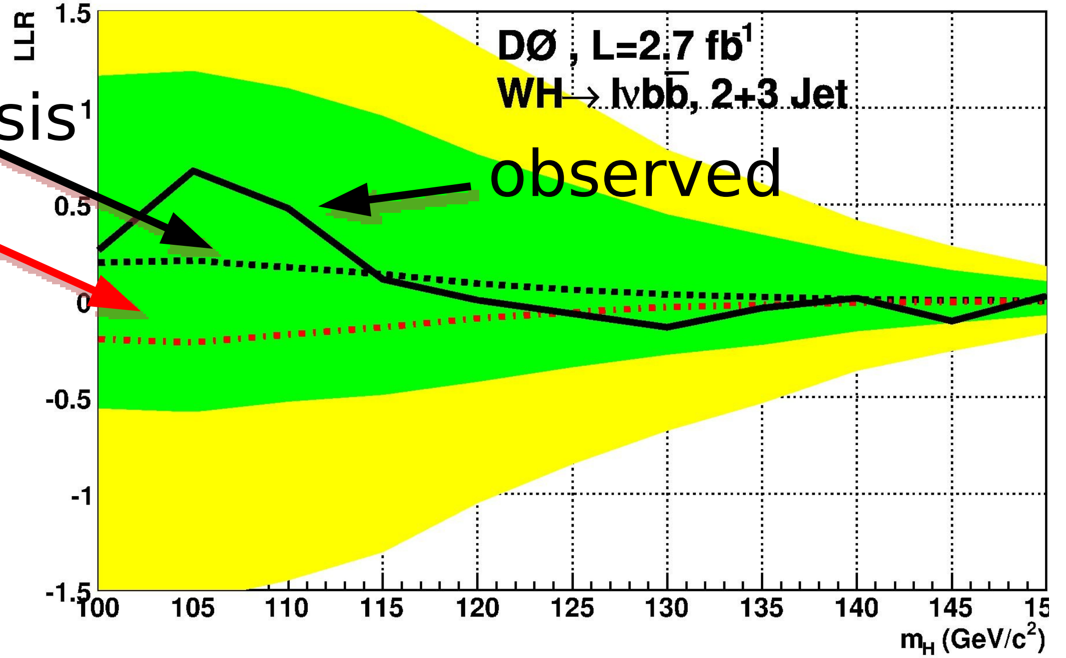
- .... at 95% of CL, modified frequentist CL_s approach

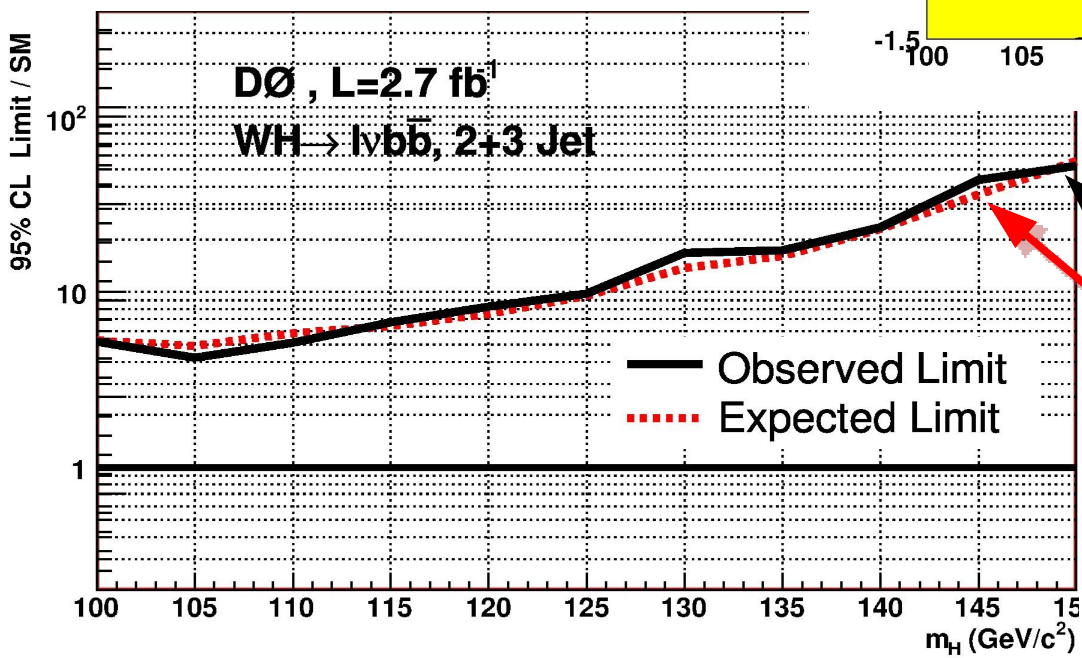
- ... using the log-likelihood ratio (of Signal+Background vs Background hypotheses) as test statistic

Results

Log-likelihood ratio:
- background (B) hypothesis
- signal + B hypothesis

± 1 std. deviation
± 2 std. deviations





σ Limit/SM:
Observed
Expected

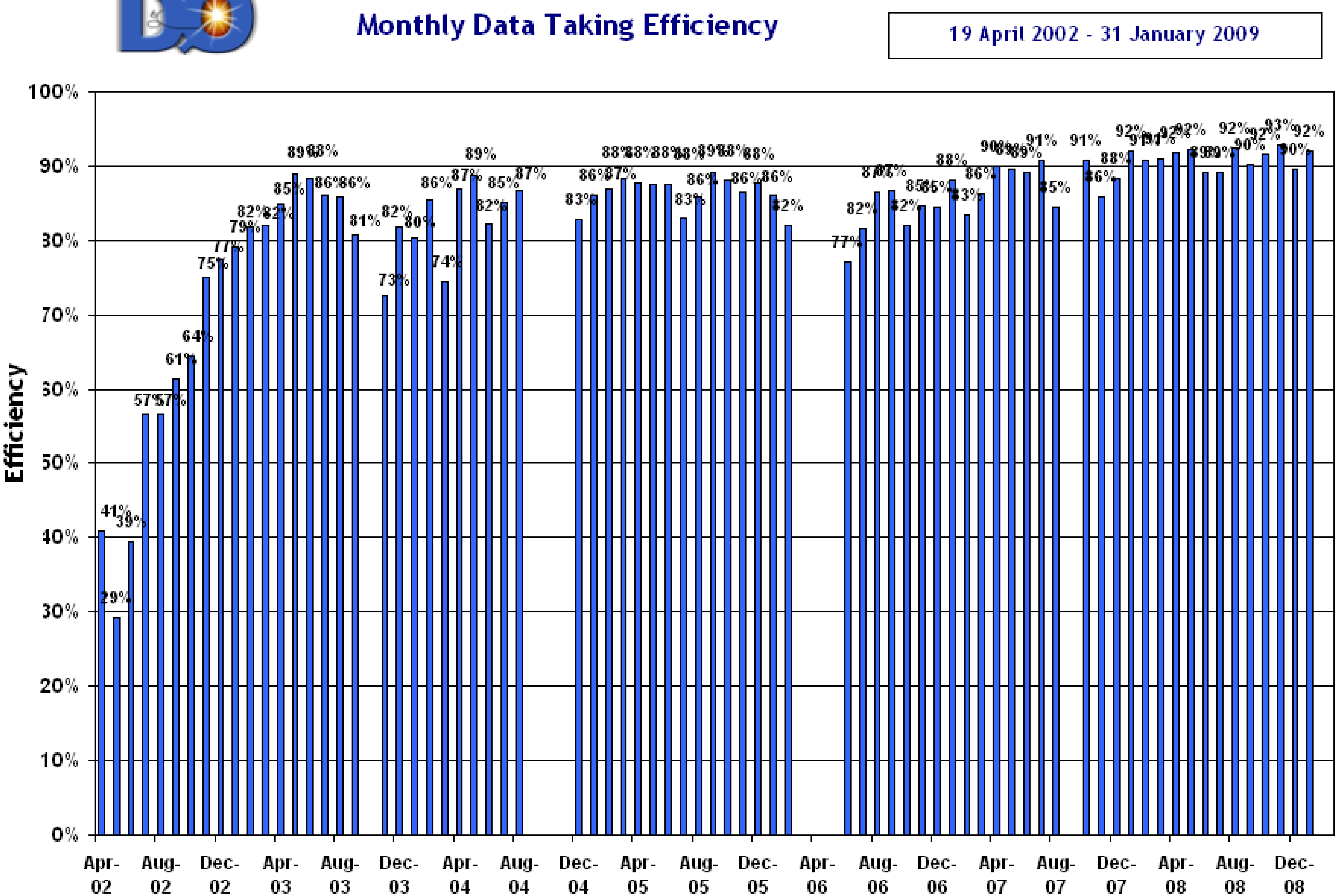
@115 GeV:
exp (obs) : 6.4 (6.7)

Conclusion

- Improvements underway
  - Further improvements in lepton identification
  - Improvements in b-tagging (e.g., b/c separation)
  - Multivariate analysis in 3-jet final states
  - ...
  - Additional integrated luminosity (twice as much data already available)
- Combining it with other DØ and CDF low mass analysis should give a limit at 2xSM σ @115 Gev

Backup

Data taking efficiency



Electron/muon definitions

- Electron:
  - Energy in hollow cone ($\Delta R=0.2, 0.4$)/ Electron Energy < 0.15
  - Shower shape requirement
  - Matched to a track
  - Likelihood discriminant

- Muon:
  - Isolated (ΔR) from the jets
  - Low calorimeter and tracker activity around the muon candidate